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- USAFOEHL REPORT

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CONTAMINATION OF THE EXTERIOR OF A C-130E AIRCRAFT USED FOR AERIAL SPRAY, 907 TAG, RICKENBACKER ANGB OH

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Final Report

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Contamination of the exterior of a C-130E aircraft was evaluated during flight tests of a new modular aerial spray system at Dobbins AFB GA and Avon Park AFR FL. Oil sensitive cards and paper index cards were taped to 50 sites on the exterior of the aircraft to monitor deposition of Dibrom, Malathion, soybean oil, and water during aerial spray operations. Light contamination of the aileron occurred when the wing booms were used and heavy contamination of the cargo door and horizontal stabilizer occurred when the fuselage booms were used.

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I. INTRODUCTION

A. Purpose: To determine if the exterior of a C-130E aircraft equipped for aerial application of pesticides is contaminated during the following situations:

1. Application of material through wing-mounted spray system.

2. Application of material through fuselage-mounted spray system.

3. Neither spray system used (i.e., control).

B. Problem: Deposition of spray solution onto the aircraft is a concern because:

1. Some pesticides and solvents are corrosive.

2. Pesticide residue on the aircraft may constitute an occupational hazard to aircraft maintenance personnel.

3. Pesticide residue washed off the aircraft during routine cleaning may adversely affect the environment.

C. Scope

Aerial application is an effective means of rapidly dispersing pesticide over large areas unsuitable for treatment by ground equipment. UC-123K aircraft configured with spray equipment were used for many years by the USAF as the primary means of aerial spray, but a new spray system was recently designed by Lockheed Aircraft Corporation and Conair Aviation Ltd for use on C-130E aircraft. The new system, called a Modular Aerial Spray System (MASS), is composed of three separate modules for use in different configurations depending on the type, quantity, and flowrate of chemical being sprayed. One module contains a control panel and a 240 gallon stainless steel flush tank. Another module contains two 500 gallon aluminum tanks. A third module contains two 500 gallon stainless steel tanks. The MASS can be used to apply material through two spray booms mounted on the wings and two spray booms mounted on the fuselage. Each wing boom has 46 spray nozzles and each fuselage boom has 57 spray nozzles.

Contamination of the exterior of aircraft used to disperse pesticide has been previously evaluated by washing aircraft after spray operations and performing chemical analysis of the washwater.(1) Pesticides were detected, sometimes at concentrations considered toxic to aquatic organisms.(2) The US Environmental Protection Agency (EPA) addressed the issue of environmental contamination from runoff of washwater used to clean aerial spray planes and concluded that the water was not a hazardous waste under the Resource Conservation and Recovery Act;(3) however, states may establish more stringent requirements. Although such contamination is not of environmental concern, the structural integrity of aerial spray planes may be affected by chemical deposition. Buyers of used aircraft are cautioned against purchasing aerial spray planes because of possible corrosion problems.(4)

II. PROCEDURES

Preliminary tests were conducted at Dobbins AFB GA in early June 88 to determine if background contamination of the exterior of the aircraft occurred when the spray system was not operated. Two flights were conducted with the MASS onboard, but without applying any material through the wing or fuselage booms. Oil sensitive cards (7.6 x 5.1 cm) were taped (duct tape; 5 cm wide) to 50 locations for the first flight and paper index cards (10 x 15 cm) were taped to the same locations for the second flight (Fig 1). Each card was removed and stored in a separate plastic bag after each flight.

Definitive tests of the wing booms were conducted at Avon Park AFR FL in late June 88. Oil sensitive cards were taped to 50 locations (Fig 1) for four flights when Dibrom was applied, three flights when Malathion was applied, and two flights when soybean oil was applied (Table 1). The dosages for Dibrom and Malathion were recommended by the manufacturers and approved by the US Environmental Protection Agency for mosquito control. Additional pieces of oil sensitive card were taped to the back of several nozzles on the wing booms to determine if Dibrom was deposited on the area. Paper index cards were used for a single flight when water and red dye were applied. Each card was removed and stored in a separate plastic bag after each flight.

Table 1. Summary of Flight Tests of Modular Aerial Spray System on C-130E Aircraft.

Date	Material Used	Booms Operated	Nozzles Open	Nozzle[a] Tips	Flow Rate (lpm)	Droplet[b] Size (VMD)	Spray Time (min)
1 Jun 88	None	None	0	8005	0	0	0
2 Jun 88	None	None	0	8005	0	0	0
9 Jun 88	Dibrom	Wing	14	8005	21	25	3.00
10 Jun 88	Dibrom	Wing	24	8005	32	25	3.28
11 Jun 88	Dibrom	Wing	24	8005	26	25	3.65
12 Jun 88	Dibrom	Wing	24	8005	29	25	2.97
13 Jun 88	Malathion	Wing	49	8005	82	34	10.47
14 Jun 88	Malathion	Wing	25	8005	35	34	2.23
14 Jun 88	Malathion	Wing	50	8005	79	34	4.26
17 Jun 88	Soybean Oil	Wing	36	8020	227	ND	1.93
18 Jun 88	Soybean Oil	Wing	72	8020	450	ND	2.75
19 Jun 88	Red Water	Wing	92	None	778	≈377	2.81
24 Jul 88	Red Water	Fuselage	114	None	3026	308	1.33
24 Jul 88	Red Water	Fuselage	114	None	1699	108	1.53
25 Jul 88	Red Water	Fuselage	114	None	3084	308	1.50
25 Jul 88	Red Water	Fuselage	94	None	3000	338	ND
26 Jul 88	Red Water	Fuselage	66	None	3020	139	1.75

[a]TeeJet brand nozzle tips manufactured by Spraying Systems Co.

[b]VMD = Volume mean diameter (microns); the droplet size that represents 50% of the volume. Half the volume is in droplets below the VMD and half is in droplets above the VMD.

ND = No Data.

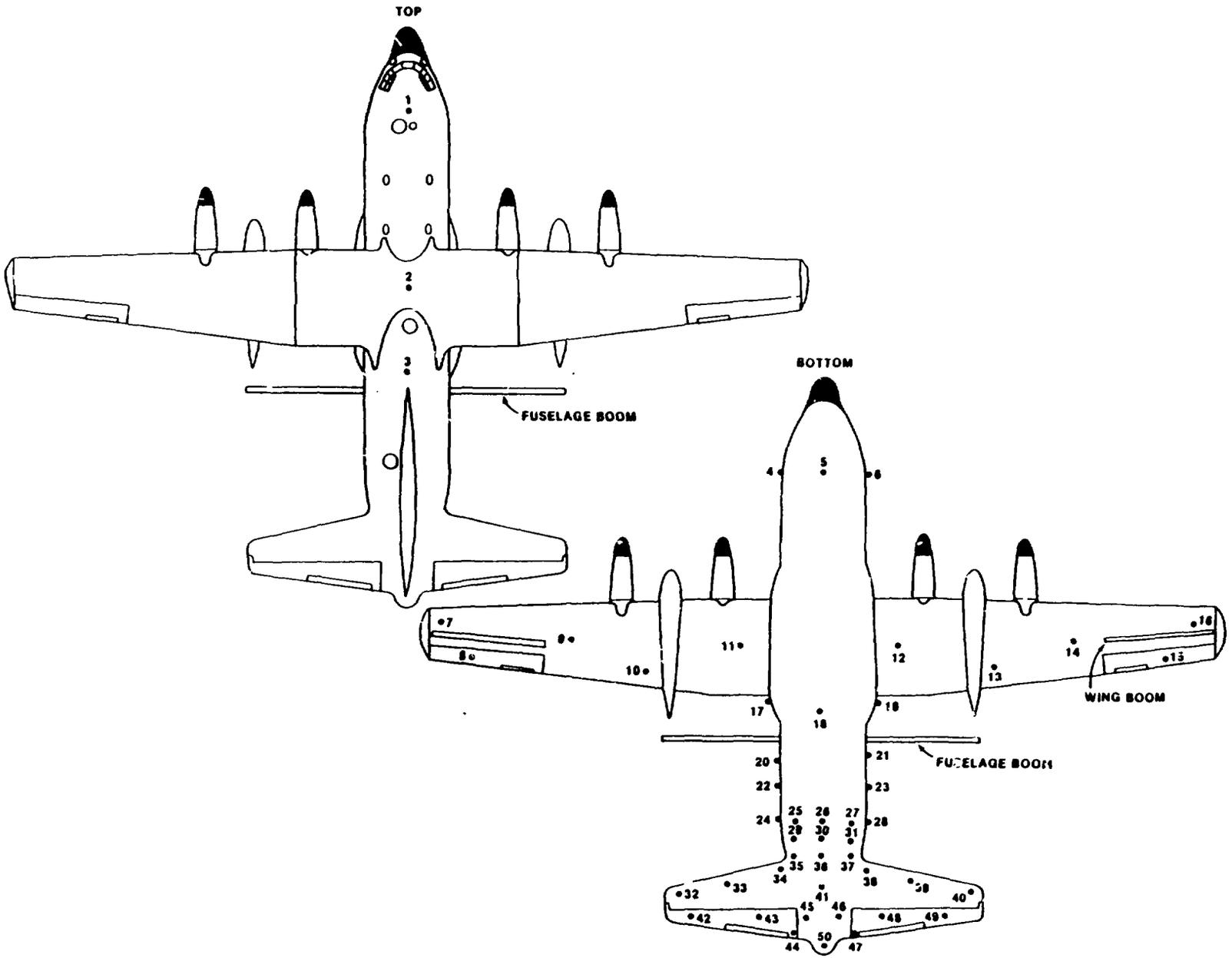

Figure 1. Location of monitoring cards on exterior of C-130E aircraft during evaluation of Modular Aerial Spray System.

In late July 88, additional tests were conducted at Avon Park AFR FL to evaluate the fuselage booms. Red dye was mixed with water and applied during five flights (Table 1). All nozzles were open on the fuselage booms for three flights, ten nozzles closest to the fuselage were closed on each boom for one flight, and 24 nozzles closest to the fuselage were closed on each boom for the final flight. Paper index cards were taped to the same locations as on previous flights (Fig 1) and each card was stored in a separate plastic bag.

Dibrom and Malathion rapidly degrade under field conditions, therefore chemical analyses were not performed. Contamination was assessed by examining oil sensitive cards for a change from white to black which occurs upon contact with an oil based substance. White paper index cards were examined for the presence of red dye. Contamination was quantified by placing plastic overlays, divided into 88 squares (1 cm^2) for paper index cards or 24 squares (1 cm^2) for oil sensitive cards, over each card to classify the extent of contamination as follows: no contamination = negative; contamination of <50% of the squares = light; contamination of ≥50% of the squares = medium; contamination of 100% of the squares with penetration to back side of card = heavy.

III. DISCUSSION

A. Test Preparation

Oil sensitive cards or paper index cards could be taped to 50 locations by one person in about 2.5 hours or by two persons in about 1.5 hours. After being taped on the aircraft, the exposed area on each oil sensitive card was approximately 29 cm^2 and the exposed area on each paper index card was approximately 99 cm^2. Most of the 850 cards used throughout the test remained intact during flights; only 26 cards blew off. Cards which frequently blew off were on top of the aircraft, near the leading edge of the wings, and near the leading edge of the horizontal stabilizer. The tape did not adhere to these areas because of skid-proof coating on the top of the aircraft, and strong air currents over the leading edge of the wings and horizontal stabilizer.

B. Preliminary Flight Tests

All paper index cards were negative after the preliminary flight test. However, background contamination occurred at locations 10, 11, 12, and 13 (Fig 1) when oil sensitive cards were used. The oil came from the aircraft engines, but it did not interfere with the evaluation because the drops were large and thus distinguishable from spray droplets. Also, negative results at the same locations during definitive tests when paper index cards were used to detect red dye, applied through the wing booms, indicates that material from the spray system did not contaminate the underside of the wings near the engines.

C. Wing Boom Flights

Light contamination of the aileron (cards 8 and 15, Fig 1) occurred when wing booms were used to apply soybean oil and water. The same locations were negative when Dibrom and Malathion were applied at lower rates with smaller droplets, however, one card (3, Fig 1) on top of the aircraft near the tail received light contamination during the third flight involving Malathion (Table 1). The aircraft most likely flew through a cloud of spray which was kept suspended by a temperature inversion. All other cards were negative on the horizontal stabilizer (Fig 2B), cargo door, wings, and fuselage when the wings booms were used. An additional piece of oil sensitive card taped to the back of a nozzle was positive after Dibrom application. The chemical moved up a low pressure area on the back of the nozzle, but did not contaminate the wing above the spray boom. This does not pose a problem because nozzles must be replaced for various other reasons after prolonged use.

D. Fuselage Boom Flights

The cargo door and horizontal stabilizer (Fig 2C) were heavily contaminated with red dye when the fuselage booms were used. Deposition of material during flight was not apparent when viewed from the ground or video films taken by a chase plane, but cards near the outer edges of the cargo door and rear fuselage were saturated with red dye. Contamination was so heavy that red dye could easily be seen on the aircraft. Some of the dye flowed up the rear of the fuselage and onto the top of the horizontal stabilizer. Spray nozzles closest to the fuselage were the most likely source of the material because the amount of contamination decreased after 10 nozzles were closed on each boom (Fig 2D) and a further decrease in contamination was observed when 24 nozzles were closed on each boom (Fig 2E).

E. Additional Observations

An accidental spill of water and red dye in the aircraft prior to the first use of the fuselage booms invalidated results of a flight. The pilot and photographer in a T-34 chase plane observed fluid running out of the bottom of the aircraft during the first flight on 24 Jul (Table 1) when the spray system was not on. Two cards (5 and 18, Fig 1) located in front of the fuselage booms and on the bottom of the aircraft were heavily contaminated during the flight. Red dye stains on the bottom of the aircraft indicated the fluid was leaking from drain holes and the landing gear well. The floor of the aircraft should be removed to completely drain excess material if future accidents involve toxic chemicals; otherwise, extensive contamination of the interior and exterior of the aircraft may occur.

Application of corrosive material such as Dibrom(5) through the fuselage booms could affect the structural integrity of the aircraft. Decontamination will be difficult if not impossible if such materials penetrate the infrastructure through seams around the cargo door. Contamination can be reduced by closing nozzles near the fuselage, but the spray deposition pattern may be affected and more flights may be required to obtain the necessary application rate.

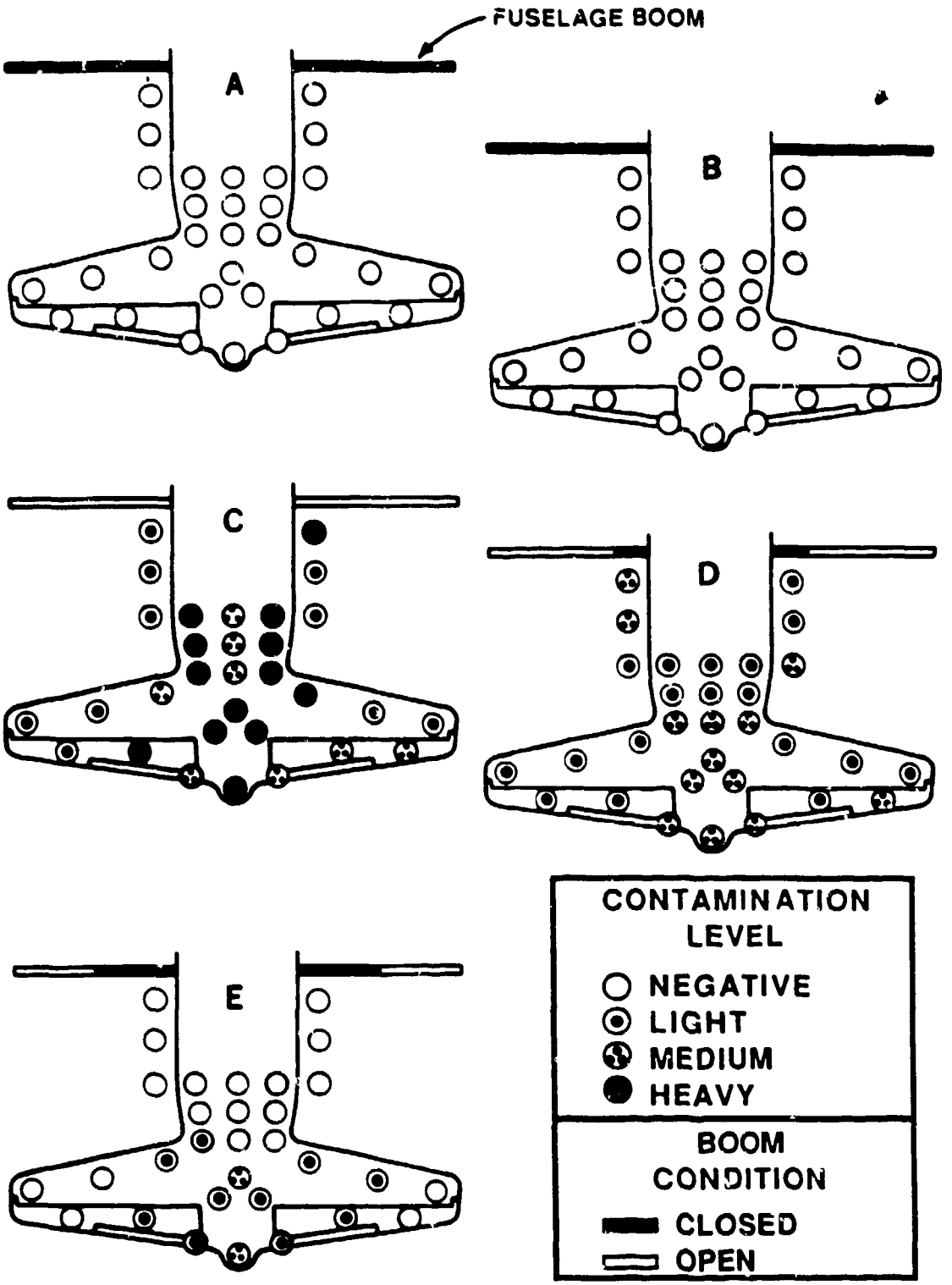

Figure 2. Contamination of the rear of a C-130E aircraft after: A. Spray system not used; B. Wing booms used; C. Fuselage booms used with 114 nozzles opened; D. Fuselage booms used with 94 nozzles opened; E. Fuselage booms used with 66 nozzles opened (view of underside of aircraft).

Removal of residue of most chemicals from the aircraft can be accomplished by washing surfaces with soap, water, and a scrub brush. This should be done around the wing booms, particularly the aileron, and behind the fuselage booms, particularly the cargo door and underside of the horizontal stabilizer. Maintenance personnel should wear coveralls, gloves, and a face shield to avoid contact with toxic chemicals when performing the task. The USEPA does not consider the washwater a hazardous waste under the Resource Conservation and Recovery Act; therefore, collection and disposal procedures are not required(3) unless the state where aerial spray is being performed has more stringent requirements.

IV. CONCLUSIONS

A. Background oil contamination occurred on the rear of the wing behind the engine. Cards positioned in other areas were negative.

B. Only one oil sensitive card was positive on the C-130 after applications of Dibrom and Malathion. The card (3, Fig 1) was on top of the aircraft where the tail joins the fuselage. This occurred when Malathion was applied during a temperature inversion; the plane most likely flew through the spray after application.

C. A piece of oil sensitive card was positive on back of a nozzle where small amounts of pesticide moved up a low pressure area. The wing of the aircraft was not contaminated in the process.

D. Paper cards on the aileron were positive after low volume and high volume applications of soybean oil and water with red dye.

E. The underside of the horizontal stabilizer and cargo door, and the side of the fuselage were heavily contaminated with red dye when all nozzles were opened on the fuselage booms (Fig 2). The amount of red dye deposited on each card decreased when nozzles closest to the fuselage were closed; however, spray deposition may have been affected. A compromise must be made if fuselage booms are used. Aircraft contamination can be reduced by closing nozzles, but additional flying may be needed to obtain complete coverage with spray material.

F. An accidental spill of pesticide within the aircraft can lead to contamination of a substantial amount of the exterior of the aircraft if it is not properly cleaned. A spill involving corrosive material such as Dibrom could greatly damage the structural integrity of the aircraft if it is not completely removed from all areas.

G. Washwater used to clean aerial spray planes is not a hazardous waste under the Resource Conservation and Recovery Act; however, it may be classified as a hazardous waste and subject to collection and disposal by some states.

V. RECOMMENDATIONS

A. The spray booms and area of the wings above and behind the booms (particularly the aileron) should be washed with soap, water, and a scrub brush within 24 hours after each flight involving application of corrosive material.

B. The fuselage booms should not be used to apply corrosive materials because the underside of the cargo door and horizontal stabilizer will be contaminated.

C. The underside of the cargo door and horizontal stabilizer should be washed with soap, water, and a scrub brush after any type of pesticide is applied through the fuselage booms.

D. Contamination of the underside of the cargo door and horizontal stabilizer can be significantly reduced by closing nozzles closest to the fuselage whenever the fuselage booms are used.

E. If an accidental spill occurs inside the aircraft, excess material must be drained from the belly of the fuselage as soon as possible to avoid extensive contamination of the exterior of the aircraft.

F. Local regulations regarding disposal of pesticide wastes including washwater used to clean aerial spray planes should be examined prior to performing aerial spray missions.

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